Industrial Health

Analysis on Chemical Ingredients with Anti-microbial Activity in Water-based Metalworking Fluids

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Abstract

This study was conducted to estimate if the level of several chemical ingredients including alkanolamines or ethanolamines (EA) examined in the specific synthetic metalworking fluid (MWF) "A" can cause anti-microbial activity and health effect. Three water-based MWF products ("A", "B", and "C") were studied every week for two months (from June 1, 2002 to July 30, 2002). Chemical ingredients such as formaldehyde, boron, EA, and copper were examined. In the sump where MWF "A" was used, not only the total level of EA, monoethanolamine(MEA), diethanolamine(DEA) and triethanolamine(TEA), but also boron level were significantly higher than those of the other MWFs. ANOVA statistical tests indicated that levels of pH, alkalinity, boron, MEA, DEA and TEA in MWF A were significantly higher than those in other MWF types. Correlation tests also found that levels of pH, alkalinity, boron, MEA, DEA and TEA in MWF "A" are significantly correlated. We suggested the assumptions that excessive concentrations of EA, and borate at a high pH level, may cause anti-microbial resistance synergically. To demonstrate this assumption, additional study is needed to examine the relationship between the levels of microbes and excessive concentrations of EA, and borate at a high pH level.

Introduction

Water-based Metalworking fluids (MWFs) are excellent nutritional sources for many kinds of bacteria and fungi. A specific synthetic MWF (designated as MWF "A"), imported from Japan, was acclaimed to have excellent anti-microbial activity. The Material Safety Data Sheets (MSDS) on MWF "A" indicated only a presence of carboxylic salts, synthetic oil, and

EA. The specific amount and type of EA were not addressed due to confidential trade secrets. The MSDS was not a useful reference for the presence, or relative amount of components. Alknanolamines or ethanolamines (EA) such as monoethanolamine (MEA), diethanolamine (DEA) and triethanolamine (TEA) may be used in soluble MWFs in order to stabilize pH or inhibit corrosion. This study was conducted to examine if their levels in a specific synthetic metalworking fluid (MWF) "A" can cause anti-microbial activity and health effect. To accomplish this purpose, several chemical ingredients that were suspected to have anti-microbial performance were investigated and compared among MWFs.

Materials and Methods

MWF type and sump studied

Three types of water-based MWFs (MWF "A", "B" and "C") were studied every week for two months (from June 1, 2002 to July 30, 2002) in a single machine shop. MWF "A", a synthetic type, was first charged to one sump called MT 01 on September 1, 2001. This MWF had been used without replacement until July 30, 2002, the end of this study. Two other products of soluble MWFs ("B" and "C") were used in six other sumps, for both longer and shorter periods than the synthetic MWF "A", again without changing the fluid.

The pH levels of the MWFs were measured in the field using a thermometer (model 230, Portable Meter, ORION). In addition, the MWF concentration was measured in the field using a refractometer (model, ATAGO N20E, Japan). Total alkalinity was analyzed in laboratory according to "method No. 2320 A" of the Standard Methods for Examination of Water and Wastewater

Analysis on chemical ingredients

Formaldehyde was analyzed by an HPLC UV-VIS absorbance detector (model, Waters Alliances, USA). A standard curve to quantify the formaldehyde in the MWF, was constructed by serial dilution of formaldehyde-DNPH stock solution (100 μg/ml in acetonitrile, Cat No. 4-7177, USA). Copper and Boron compounds in the MWFs were quantified as elements using Inductively Coupled Plasma (model OPTIMA 3,000 DV, Perkin Elma).

In order to quantify EAs, a portion of MWF sample was filtered using a micro-syringe, with a 0.4 m pore size filter, and quantified by ion chromatography (WATERS, Waters, USA) equipped with composed of a guard column (IC PAK^{Tm} C M/D, USA), column (IC PAK^{Tm} Cation M/D column, USA), and a detector (432 conductivity detector, Waters, USA).

Results

The pH level of the MWF "A" ranged from 9.01 to 9.38 (average: 9.14) and was significantly higher level than those in other sumps. Total alkalinity ranged from 15,200 ppm

to 14,700 ppm, which was far higher than the range of other sumps, 1,300 ppm～5,200 ppm. Elemental concentrations of boron in the MWF "A" were also significantly higher than those in other MWFs. ANOVA statistical tests showed that levels of pH, alkalinity, boron, MEA, DEA and TEA in MWF "A" were significantly higher than those in other MWF types.

Discussion

The levels of EA, alkalinity and boron between MWF "A" and the other MWFs ("B" and "C") were significantly different. In particular, high level of EA and alkalinity were found in MWFs "A". Sandin et. al. (1990) found that the anti-microbial effects of alkanolamine such as DEA are greatly enhanced at a high pH. Rossmoore (1993) studied the dual role of pH and EA in contribution to bio-stability in MWF, and found that a high pH (i.e., about 10) produced a degree of bio-stability. Hernandez et al. (1984) reported the anti-microbial performance by boron-amine interaction with three types of synthetic formulations. Our study found significant difference in pH, boron, MEA, DEA and TEA between MWF "A" and the other two MWF. Statistical tests indicated that the levels of pH, boron, MEA, DEA and TEA were significantly correlated. Our study results suggest the assumption that a high EA level in combination with borate at a high pH (9.01～9.38) can lead to anti-microbial resistance in MWF "A".

Conclusions

Our study found that levels of pH, alkalinity, boron, MEA, DEA and TEA in MWF "A" were significantly higher than those in other MWF types and correlated. Abuse of EA and boron could contribute to strong anti-microbial performance in MWFs. These study results suggest the assumption that a high EA level in combination with borate at a high pH (9.01 ～9.38) can lead to anti-microbial resistance in MWF "A".

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